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THE MIDDLE PALEOZOIC STRATIGRAPHY OF THE CENTRAL ROCKY MOUNTAIN REGION¹

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¹ An abridgment of a thesis presented for the degree of Doctor of Philosophy at the University of Chicago, 1916.

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PART I

FOREWORD

This paper is the result of three months' field work by the writer in the central Rocky Mountain region during the summer of 1915, under the auspices of the University of Chicago. For assistance in planning the field investigation the writer is indebted to Dr. Eliot Blackwelder, of the University of Wisconsin, and to Dr. R. D. Salisbury, of the University of Chicago; for aid in the identification of fossils, to Dr. Stuart Weller, of the University of Chicago; and for helpful suggestions and criticism of the material of the thesis, to all of these gentlemen.

The problem centered about several broad gaps in the existing knowledge of the Ordovician, Silurian, and Devonian history of western Wyoming and adjacent parts of neighboring states; for example: (1) the "Jefferson limestone" of the Absaroka Range, of Yellowstone National Park, and of southwestern Montana was known to be in part Devonian, but the presence of Ordovician and Silurian strata within this formation and its relation to the Bighorn dolomite of central and north-central Wyoming were matters of dispute; (2) hiatuses were suspected at the base and at the top of the Ordovician-to-Devonian sequence of this region, and at more than one horizon within that sequence, but no physical evidence of any such hiatus ever had been cited; (3) the relation of the Wyoming Ordovician and Upper Cambrian to the corresponding systems in northeastern Utah had never been studied by careful stratigraphic comparison; and (4) the relation of the Silurian to the Ordovician in northeastern Utah was unknown.

By first-hand studies, in one season, of ten complete, and in most cases excellently exposed, sections at strategic localities scattered throughout the area involved, the writer is enabled to throw considerable new light upon all of these questions.

Because of the well-known scarcity of fossils in the strata which were to form the subject of his investigation, the writer set out with intent to make the greatest possible use of correlation by means of lithologic characters. To this end he made accurate measurements and described in detail, in every section, each member of the sequence which could be distinguished from other members by its lithological characters. Collections of fossils, although made secondary to the work of lithological description and measurement, and in no case exhaustive, were made wherever opportunity presented itself, and in each case served to corroborate the correlation which otherwise would have been made on the basis of lithology alone. For instance, the presence of the Ordovician Bighorn dolomite as the thick basal member of the so-called "Jefferson limestone" in the areas of the Absaroka, Wyoming (No. 52), and Livingston, Montana (No. 1), was established beyond doubt by both lines of evidence, though it would have been well established by either one alone.

In these correlations it was realized that the coincidence of the lithological characters of a single member at one locality with those of one member in the same stratigraphic position in another locality is much more inconclusive (although significant) than the correspondence of several successive members in one section to the same number of members occurring in the same order and in the same stratigraphic position in another. In nearly every case where a single bed in one section was found to correspond accurately in character to one bed in another section, not less than two other contiguous members were found to correspond in like manner. Where several members of one section appeared to be missing from another section, a hiatus was inferred in the latter; and such inference was substantiated in several cases by more direct evidence at the suspected horizon.

LOCATIONS OF SECTIONS MEASURED, 1915

(See map, Fig. 1)

I. (Partial.) In the northwest wall of the canyon of Big Goose Creek, about 20 miles southwest of Sheridan, Wyoming.

II. *Goose Creek Ridge*.—On the crest of the "limestone front ridge" on the northeast flank of the Bighorn Range, between Big and Little Goose creeks, about 20 miles southwest of Sheridan, Wyoming.

III. *Cody, Rattlesnake Mountain*.—On the southwest angle of Rattlesnake Mountain, north of Shoshone Dam, 9 miles west of Cody, Wyoming.

IV. *Dead Indian Creek*.—On the nose of the main ridge running parallel to the valley of Dead Indian Creek on the southeast side thereof, just south-

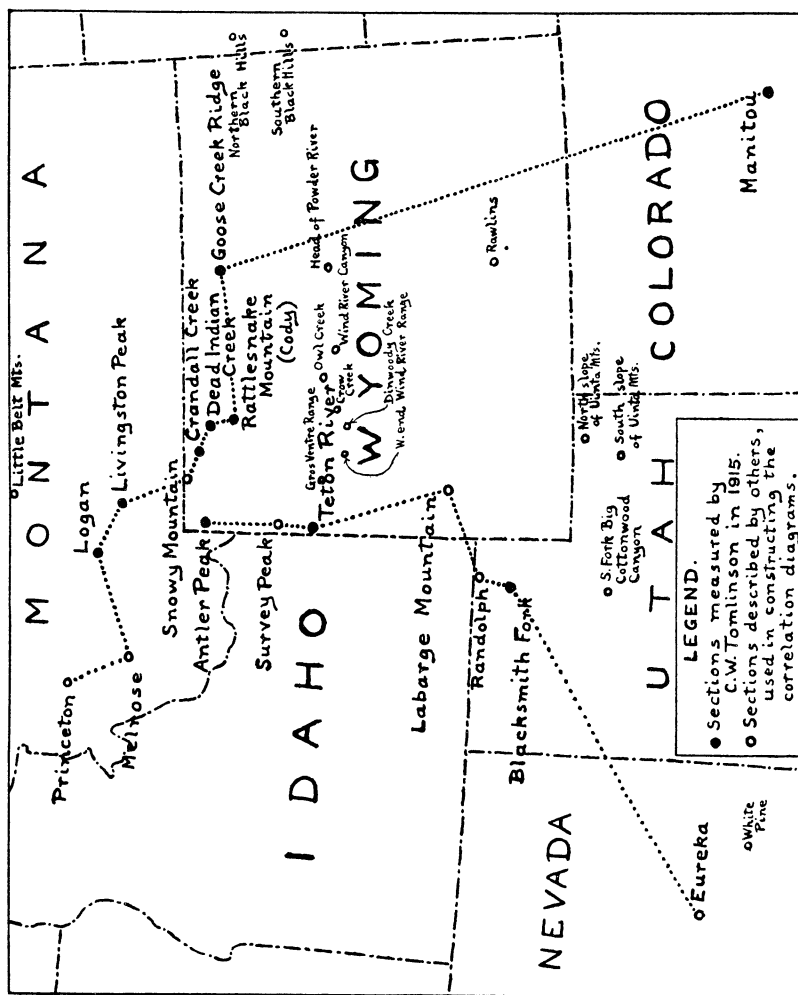


FIG. 1.—Map showing localities referred to in this paper

west of the crossing of the road from Cody to Sunlight Basin, Wyoming, a few miles east of the east border of the Crandall quadrangle.

V. *Crandall Creek*.—At the west end of the north slope of Windy Mountain, in the south wall of the valley of Clark Fork, near the mouth of Crandall Creek, in the Crandall quadrangle (Absaroka Folio), Wyoming.

VI. (Incomplete.) *Aniler Peak*, Gallatin Range, Yellowstone Park, Wyoming.

VII. (Cambrian only.) On the ridge running west from the summit of Livingston Peak, Livingston quadrangle, Montana, about one mile north of "Old Baldy."

VIII. *Livingston Peak*.—On the south slope of Livingston Peak, on the ridge leading to "Old Baldy" (the 9,500-foot peak 1 mile southwest of Livingston Peak), Livingston quadrangle, Montana.

IX. *Logan, Montana*.—On the ridges north of the Gallatin River, opposite Logan, in the Three Forks quadrangle, Montana.

X. *Teton River*.—On the divide between Teton River and South Leigh Creek, Grand Teton quadrangle, Wyoming.

XI. *Blacksmith Fork* (including the Cambrian).—Measured across the ridges just north of the canyon of Blacksmith Fork, Cache County, Utah, from Cottonwood Gulch to the crest of Logan Peak, west of Saddle Creek.

XII. *Manitou*.—Measured on the ridges from one to two miles northwest of Manitou, Colorado.

STRATIGRAPHY

THE CORRELATION DIAGRAMS

Use of the diagrams.—Detailed descriptions of the 12 sections above listed cannot be printed here. A consistent application of the principles of correlation outlined on pp. 115, 122, however, has made it possible to formulate a standard list of members. Each of the 12 sections is made up of a part or all of the members in this list (see pp. 123–28), and includes no others. By combining these members in the manner indicated by the accompanying correlation tables (Figs. 2, 3) and diagrams (Figs. 4, 5), every one of the 17 stratigraphic sections used in the compilation of the list can be reconstructed. For instance, the Devonian system in the Crandall Creek section is made up of Member 1, with a thickness of 47 feet, overlain by Member 2, 26 feet thick, which is followed by Member 3, 28 feet thick, and so forth. Even if some of the strata in a given section be erroneously placed in the correlation table, yet the table and the standard list of members will furnish a correct description of that section, with accurate measurements of its constituent parts.

The description of each member is given in considerable detail, but is sufficiently generalized in each case to cover all observed variations in character from place to place. In the few cases where

PERIOD	FORMATION	DIVISION	MEMBER	EUREKA (Hague)	BLACK-SMITH FORK *	RAN-DOLPH (Richards)	LABARGE MOUNTAIN (Miller, Kindle)	TETON RIVER *	SURVEY PEAK (Addings & Weed)	ANTLER PEAK *	PRINCETON (Kindle)	MEL-ROSE (Kindle)	LOGAN *	LIVINGSTON PEAK *	SNOWY MOUNTAIN (Weed)	CRAN-DALL CREEK *	DEAD INDIAN CREEK *	RATTLE MOUNTAIN (Cody)	GOOSE CREEK RIDGE *	MAN-ITOU *	MEMBER	
SILURIAN	LAKETOWN	UPPER	1	1984	(123-125)	1000 ±															1	
			8		755																	8
			9																			9
			8																			8
			7																			7
ORDOVICIAN	BIG HORN	LOWER	6																		6	
			5																		5	
			4																		4	
			3																		3	
			2																		2	
CAMBRIAN	ST. CHARLES	GARDEN PEAK	1																		1	
			0																		0	
			1																		1	
			2																		2	
			3																		3	

* indicates section measured by C.W. Tomlinson, 1915.

Figures in parentheses refer to beds in the described sections.

The larger figures indicate thickness.

* indicates section measured by C.W. Tomlinson, 1915.

Figures in parentheses refer to beds in the described sections. The larger figures indicate thickness.

FIG. 2.—Correlation table for the Cambrian, Ordovician, and Silurian systems

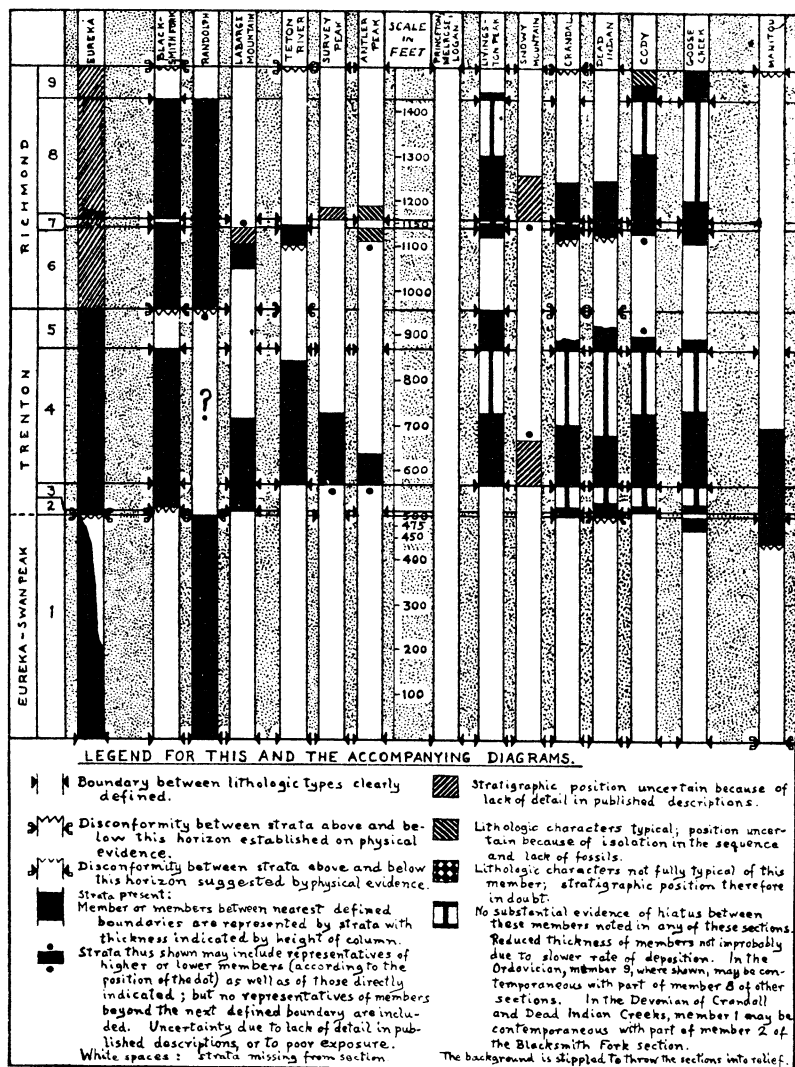


FIG. 4.—Correlation diagram for the Ordovician system, drawn to scale

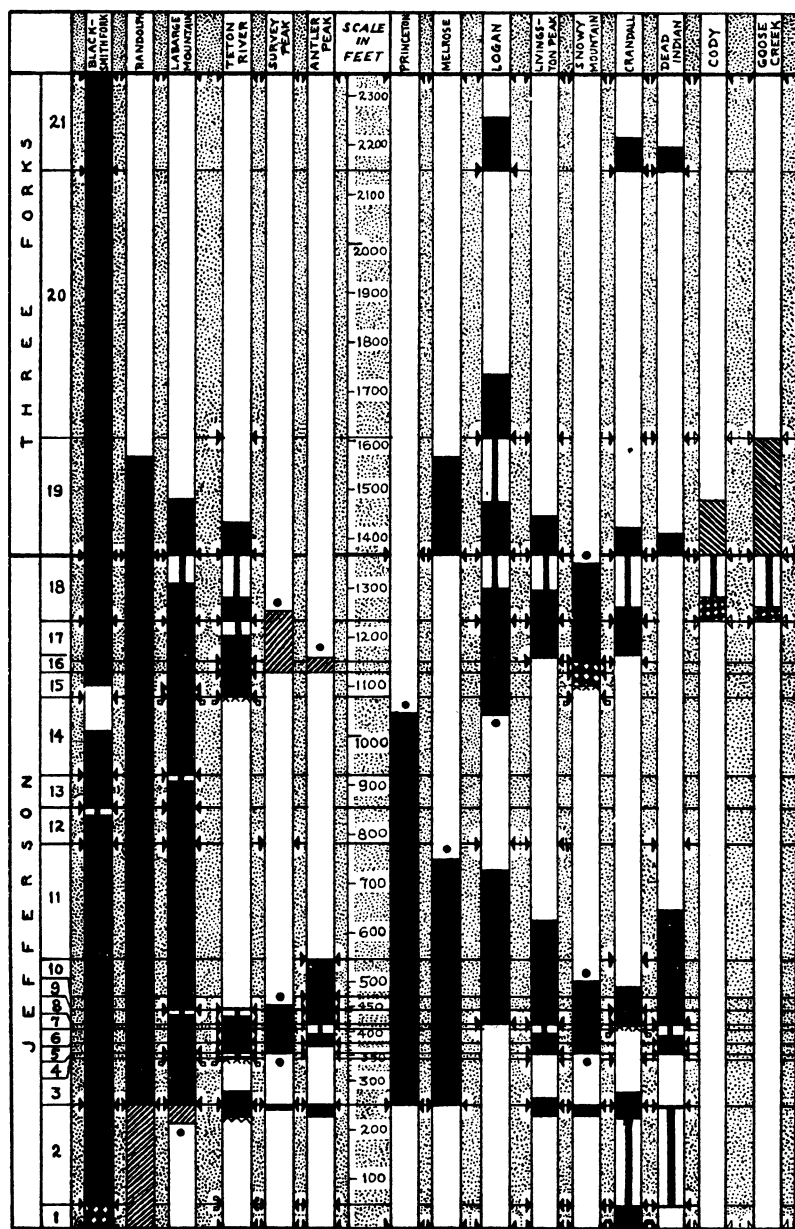


FIG. 5.—Correlation diagram for the Devonian system, drawn to scale

such variations are conspicuous or important they are specifically described for the locality where they were noted.

The standard list of members, together with the detailed correlation tables (Figs. 2, 3), in effect furnishes a compound section for 17 different localities in the central Rocky Mountain region.

Method of correlation.—In making the correlations here set forth the notes and the specimens from each section were carefully compared with the notes and the specimens from every other section, at first singly, then in groups. When a thorough and comprehensive tentative plan of correlation had been completed, all of the specimens from all the sections were laid out on a specially prepared floor, marked off into intersecting columns and rows, so that comparison of all the specimens thought to belong to a given horizon could be made at once, and at the same time all possible alterations in the proposed plan of correlation could be considered with the specimens in view. Happily, the original plan stood the test with very few changes, and those were of minor consequence.

All available paleontological data were carefully studied to determine as accurately as possible the age of the several members.

This correlation is not to be considered as final in all details, and even a few of its larger features are still clouded by uncertainty due to lack of data. The points in doubt are indicated in the diagrams and discussed in the pages following.

Sources of data.—The 7 sections, other than those measured by the writer, which are embodied in the correlation were taken from the following sources:

Eureka District, Nevada.—Arnold Hague, "Geology of the Eureka District, Nevada," *U.S. Geol. Survey, Monographs*, XX (1892).

Randolph quadrangle, Utah.—G. B. Richardson, "The Paleozoic Section in Northern Utah," *Amer. Jour. Sci.*, 4th Ser., XXXVI (1913), 406-18.

Labarge Mountain, Wyoming.—Eliot Blackwelder, unpublished manuscripts, *U.S. Geol. Survey*; E. M. Kindle, "The Fauna and Stratigraphy of the Jefferson Limestone in the Northern Rocky Mountain Region," *Bull. Amer. Pal.*, IV, No. 20 (1908), 12-13.

Survey Peak, Wyoming.—J. P. Iddings and W. H. Weed, "Descriptive Geology of the Northern End of the Teton Range," *U.S. Geol. Survey, Monographs*, XXXII, Part 2 (1899), chap. iv, p. 180.

Princeton, Montana.—E. M. Kindle, *op. cit.*, p. 10.

Melrose, Montana.—E. M. Kindle, *op. cit.*, p. 9.

Snowy Mountain, Wyoming.—W. H. Weed, "Geology of the Southern End of the Snowy Range," *U.S. Geol. Survey, Monographs*, XXXII, Part 2 (1899), chap. vi, pp. 206, 213-14.

With the exception of Blackwelder's section at Labarge Mountain none of these was described in detail, and the correlation given for them is of necessity very general and subject to thoroughgoing revision.

Additional data on the thickness of Cambrian and Mississippian members were secured from the following sources:

Teton River, Wyoming.—Eliot Blackwelder, unpublished manuscripts, *U.S. Geol. Survey*.

Antler Peak, Wyoming.—J. P. Iddings and W. H. Weed, "Descriptive Geology of the Gallatin Mountains," *U.S. Geol. Survey, Monographs*, XXXII, Part 2 (1899), chap. i, p. 22.

Logan, Montana.—A. C. Peale, "Description of the Three Forks (Montana) Sheet," *Geol. Atlas U.S.*, Folio 24 (1896).

Livingston Peak, Montana.—Arnold Hague, "Description of the Livingston (Montana) Sheet," *Geol. Atlas U.S.*, Folio 1 (1894).

Crandall Creek, Wyoming.—Arnold Hague, "Description of the Absaroka Quadrangle," *Geol. Atlas U.S.*, Folio 52 (1899).

Rattlesnake Mountain, Wyoming.—C. A. Fisher, "Geology and Water Resources of the Bighorn Basin, Wyoming," *U.S. Geol. Survey, Prof. Paper No. 53* (1906), p. 14.

Goose Creek Ridge, Wyoming.—N. H. Darton, "Description of the Bald Mountain and Dayton Quadrangles," *Geol. Atlas U.S.*, Folio 141 (1906).

Princeton, Montana.—W. H. Emmons and F. C. Calkins, "Geology and Ore Deposits of the Philipsburg Quadrangle, Montana," *U.S. Geol. Survey, Prof. Paper No. 78* (1913).

Data concerning the Three Forks formation near Logan, Montana, were taken from:

W. P. Haynes, "The Fauna of the Upper Devonian in Montana, Part 2, The Stratigraphy and the Brachiopoda," *Annals of the Carnegie Museum*, X (1916), 16-17.

STANDARD LIST OF MEMBERS

CONSTITUTING THE MIDDLE PALEOZOIC SECTION IN WESTERN WYOMING,
SOUTHWESTERN MONTANA, AND NORTHEASTERN UTAH

(M.T. = Maximum thickness known in this region)

MISSISSIPPIAN

3. Main body of the Madison limestone. Interbedded massive and flaggy limestones, blue-gray, gray, brown, or black, crystalline to dense, with some layers abundantly fossiliferous. Chert of local occurrence only. M.T.,

2,000 feet, more or less, in Utah. 1,500 feet in the Livingston quadrangle, Montana.

2. Coarsely crystalline, very fossiliferous limestone, free from chert. M.T., 150 feet, Snowy Mountain section, Yellowstone Park.
1. Very hard, cherty, black or gray limestone. Fossils few or fragmentary. M.T., 175 feet, Snowy Mountain. (Members 1 and 2 of the Mississippian are differentiated from Member 3 only in Yellowstone Park and vicinity.)

DEVONIAN

(Member 21 may prove to be of Mississippian age; Members 1 and 2 may be Silurian.)

Three Forks Formation

(M.T., 978 feet, Blacksmith Fork)

- 21 (=Haynes's 1, 2, and 3). Thin-bedded or papery black shales, overlain by yellow or reddish sandstone, sandy shales, or arenaceous limestones. M.T., 197 feet, Blacksmith Fork.
- Break in Sedimentation
- 20B. Blue-gray platy or nodular limestone. M.T., 361 feet, Blacksmith Fork (Beds 146B-149).
20. (=Haynes's 4 and 5). Fissile green shale, capped by nodular gray limestone, both very fossiliferous; the horizon of the *Clymenia* fauna in Montana. 130 feet, Logan, Montana. M.T., of Members 19 and 20 together, 420 feet, Blacksmith Fork (Beds 146-146A).
19. (=Haynes's 6 and 7). Orange-yellow to reddish platy limestones and calcareous shales (drab to cream or yellow on fresh surfaces). 109 feet, Logan (238 feet, Goose Creek Ridge).

Upper Division of the Jefferson Dolomite

(M.T., 270 feet, Blacksmith Fork)

18. Brecciated ($\frac{1}{4}$ -inch to $\frac{3}{4}$ -inch fragments) drab to gray-brown, massive dolomite, in most places forming cliffs. M.T., 136 feet, Blacksmith Fork.
17. Drab, yellow, and buff to dark-brown, thin-bedded limestones or dolomites, locally in part shaly. M.T., 85 feet, Livingston Peak.
16. Moderately massive dolomite, gray to brown, with rough surface. Sparingly fossiliferous in Yellowstone Park. M.T., 40 feet, Antler Peak (Iddings and Weed).
15. White or variegated sandstone, locally represented by light-gray dolomite full of coarse quartz grains, or by limestone conglomerate(?) (Snowy Mountain). In the Teton River section, interbedded with dark-brown,

pitted dolomite, probably representing part of Member 16. 19 feet, Labarge Mountain; 51 feet total, Teton River.

. Break in Sedimentation

Main Division of the Jefferson Dolomite

(M.T., 681 feet, Labarge Mountain)

14. Imperfectly exposed. Ledges of fine-grained, brown dolomite. Float of thin-bedded, drab and buff dolomite also. M.T., 160 feet, Labarge Mountain.

13. Cliff-making, steel-gray or gray-brown, fine-grained, calcitic, pitted dolomite. M.T., 65 feet, Blacksmith Fork.

12. Very poorly exposed. Float of thin-bedded, light-gray and buff dolomite, very calcitic, grayish-brown dolomite, and calcareous shale. M.T., 72 feet, Labarge Mountain.

8-11. Main body of the Jefferson dolomite in Wyoming and Montana. Blackish to light-brown and brownish-gray, thick-bedded dolomite, weathering to brown-gray or gray. Very fetid odor on fresh fracture. Characteristically with a rough weathered surface. Locally calcitic, or with some layers mottled and streaked with buff. Locally quite fossiliferous at certain horizons. 312 feet, Logan; probably somewhat more at Labarge Mountain and at Blacksmith Fork.

10. (Differentiated at Antler Peak only.) Brown and drab to whitish dolomite with yellow-brown bands. M.T., 75 feet, Antler Peak.

9. Dark-brown, saccharoidal, fetid dolomite, with rough weathered surface. M.T., 28 feet, Antler Peak.

8B. White, drab, or pearl-gray dolomite, conspicuous because of its light color. M.T., Labarge Mountain (Bed 16), 3 feet; Teton River (Bed 26), 1 foot 6 inches; Antler Peak (Bed 10), 3 feet; Crandall Creek (Bed 43), 2 feet 6 inches.

8A. Light-brown to blackish-brown, fine-grained dolomite. M.T., 28 feet, Antler Peak.

6-7. Dense to finely crystalline, white, cream, or pale-gray dolomite, platy to blocky. M.T., 37 feet, Teton River. In the Crandall Creek section sedimentation appears to have recommenced with Member 7 after an interval of nondeposition.

5. Fine-grained or saccharoidal, dark-brown, fetid dolomite, with irregular, pitted, weathered surfaces. M.T., 23 feet, Dead Indian Creek.

4. White friable sandstone at Labarge Mountain, elsewhere represented, like Member 15, by a bed of quartz grains more or less closely packed together in a matrix of white or yellowish dolomite. M.T., 10 feet, Labarge Mountain.

. Break in Sedimentation (?)

Basal Division of the Jefferson Dolomite

(M.T. for Wyoming, 101 feet, Crandall Creek)

3. Fetid, dark-brown, saccharoidal dolomite, mostly thin-bedded. M.T., 95 feet, Labarge Mountain.
 2. White, light-drab, or very pale lavender, dense or finely crystalline dolomite, breaking up into small, sharply angular talus. Locally carries ostracods. M.T., 202 feet, Blacksmith Fork. (Probably included with the Silurian by Kindle and Richardson in Utah because of its light color. Possibly of Silurian age.) Lies directly on the Ordovician in many sections, locally with marked disconformity.
 1. (Typically developed in the Crandall Creek section only.) Thin-bedded, greatly variegated dolomite, with thin bands of red shale and black chert. Dolomites saccharoidal to very dense and closely laminated. Thin limestone conglomerate at the base. Lies directly upon the Ordovician at Crandall Creek. M.T., 47 feet, Crandall Creek.
- Break in Sedimentation
- (In Wyoming and Montana; not in Utah?)

SILURIAN

(Not known in Wyoming, Montana, or Colorado; typically developed at Blacksmith Fork, Utah, where it includes the following members:)

8. Massive, brown-gray dolomite, medium finely crystalline, with rough weathered surface. 190 feet.
 7. Thin-bedded, slabby limestone. 5 feet.
 6. Massive, pearl-gray or whitish limestone, medium finely crystalline, with hackly talus; lower 45 feet contains abundant nodules of snow-white chert like Member 5. 140 feet.
 5. Massive white chert, with many quartz geodes. 10 feet.
 4. Extremely massive, cream-colored, coarsely crystalline dolomite. Upper 20 feet contains much chert like Member 5. Basal 5 feet full of internal casts of a Pentamerid shell. 145 feet.
 3. Massive, cream-colored or brownish dolomite, medium fine-grained, weathering to smooth surfaces. 15 feet.
 2. Like Member 8. 138 feet.
 1. Like Member 4. Basal 20 feet crowded with casts of Pentamerids and corals. 112 feet.
- Marked Disconformity

MIDDLE AND UPPER ORDOVICIAN

Richmond (Upper Bighorn, Upper Fish Haven)

9. White to light-gray or buffish, dense to coarsely crystalline dolomite, mostly thin-bedded. Less resistant than Member 8. Cherty and very fossiliferous at Goose Creek Ridge. M.T., 68 feet, Goose Creek Ridge.

8. Cliff-making, massive dolomite, locally with algal structure. Light-buff to brownish (dark-brown at Blacksmith Fork). In the Absaroka Range, partly brecciated, mottled, brownish fragments in buff matrix. Sparingly fossiliferous at Goose Creek Ridge. M.T., 270 feet, Blacksmith Fork.
7. White to dark-drab or brown-gray, dense dolomite. Weak, breaking to small angular fragments. Locally carries ostracods. M.T., 17 feet, Goose Creek Ridge.
6. Basal dolomitic breccia or conglomerate (not seen in Goose Creek Ridge section), interleaving with, and giving place upward to, a massive, brown-gray dolomite containing much calcite in seams and geodes, or to white or drab, finely crystalline dolomite somewhat similar to Member 5. The white dolomite carries corals at Goose Creek Ridge. M.T., 181 feet, Blacksmith Fork, where the two types of dolomite above described occur interbedded.

Trenton (Lower Bighorn)

5. Typically white, almost chalky, fine-grained dolomite, breaking into small angular fragments with relatively smooth weathered surfaces. At Livingston Peak interbedded with more coarsely crystalline, brownish dolomite. Locally carries ostracods. 56 feet, Dead Indian Creek (typical throughout). M.T., 89 feet, Livingston Peak.
 4. Cliff-making, massive (rarely slabby), white to light-gray or light-buff dolomite, medium to very coarsely crystalline, in many places in part with brecciated structure. Sparingly fossiliferous in many localities. 147 feet, Labarge Mountain. M.T., 153 feet, Blacksmith Fork, where it is underlain by 149 feet of massive, dark-brown dolomite, medium finely crystalline, with many seams of calcite (both members included under Member 4 in the diagrams).
 3. Like Member 4, but thin-bedded or closely jointed, weak. M.T., 60 feet, Labarge Mountain.
 2. (Recognized in the Crandall Creek and Dead Indian Creek sections only.) Cream to buff, finely crystalline dolomite in 2-foot beds. Fossiliferous. M.T., 10 feet, Dead Indian Creek.
 1. In Wyoming, developed as a white to buff or rose sandstone, mostly soft and friable; fossiliferous, locally with fish remains. 29 feet (plus?), Goose Creek Ridge. Correlated with the Harding sandstone of Colorado. At Manitou, very arkosic, and in part deeply stained (red and green); 47 feet thick. Possibly contemporaneous with part of the Swan Peak quartzite. Possibly of Black River rather than Trenton age.
- Marked Disconformity

Swan Peak Quartzite

Five hundred feet thick, in the Randolph quadrangle, northern Utah. Geneva sandstone or quartzite, north end of the Wasatch Mountains, Utah. Eureka quartzite, 200 to 500 feet thick, east-central Nevada.

UPPER CAMBRIAN AND EARLY ORDOVICIAN

4. (Known at Blacksmith Fork only.) 640 feet. Includes the following types, in descending order:

Thin-bedded, light-gray, finely crystalline dolomite; in the upper part interbedded with olive shales and very fossiliferous. 206 feet. (Beekmantown.)

Fossiliferous, dark blue-gray or blue-black, very finely crystalline dolomite with much black chert throughout, and a 30-foot bed of black chert at the base. 156 feet. (Beekmantown.)

Brownish-gray to bluish-gray, finely to coarsely crystalline dolomite in 1-foot to 5-foot beds. 278 feet.

3. Mostly thin-bedded to shaly, bluish-gray to brownish-gray, finely crystalline dolomite and dolomitic shale, with many layers of *flat-pebble limestone conglomerate*. In part fossiliferous. M.T., 800 feet, Blacksmith Fork (lower 190 feet, Upper Cambrian, placed in the St. Charles formation by Walcott; remainder Ordovician). This member is represented throughout northern and western Wyoming and southwestern Montana.
2. (Not differentiated except at Blacksmith Fork.) Finely to coarsely crystalline, gray dolomite, mostly thin-bedded, weak; in part oolitic. 349 feet, Blacksmith Fork.
1. Very massive, cliff-making, coarsely crystalline white dolomite, interbedded near the top and bottom with minor beds of thinner-bedded gray dolomite. M.T., 412 feet, Livingston Peak.
- o. Mostly thin-bedded, white to light- and dark-gray, finely to coarsely crystalline dolomite, locally with much sandstone in lower part, and with interbedded flat-pebble limestone conglomerate. In part fossiliferous. Lower (barren) half called Middle Cambrian by Walcott at Blacksmith Fork (upper part of the Nounan formation). M.T., 654 feet, Blacksmith Fork.

PALEONTOLOGICAL COLLECTIONS: ASSEMBLED LISTS

DEVONIAN

Members 5-II:

Actinostrota sp. Antler peak, Livingston Peak.

Alveolites goldfussi Billings. Livingston Peak.

Anplexus cf. *hamiltoniae* Hall. Antler Peak.

Blothrophyllum (?) cf. *cinctutum* Davis. Antler Peak.

Zaphrentis (?) sp. Livingston Peak.

Atrypa missouriensis Miller. Livingston Peak.

Bryozoa. Antler Peak, Livingston Peak (2 sp.).

Member 3:

Atrypa missouriensis Miller (fragmentary). Teton River.

Member 2:

Unidentifiable brachiopod and gastropod fragments. Teton River.

Leperditia sp. Livingston Peak, Teton River (2 sp.).

SILURIAN (BLACKSMITH FORK ONLY)

Member 8, 10 feet below top:

Syringopora cf. *verticillata* Goldfuss.

Member 4, base:

Favosites sp.

Zaphrentis(?) sp.

Conchidium knighti Sowerby.

Pentamerus cf. *oblongus* Sowerby.

Member 2:

Syringopora sp.

Member 1:

Favosites sp.

Conchidium knighti Sowerby.

Pentamerus cf. *oblongus* Sowerby.

UPPER ORDOVICIAN (RICHMOND)

Member 9. (Goose Creek Ridge only.)

Calapoecia(?) cf. *anticostiensis* Billings.

C. cribriformis (Nicholson).

Favosites (n.sp.?).

Halysites gracilis (Hall).

Streptelasma sp.

Crinoid fragments.

Rhynchotrema sp.

Zygospira modesta(?) Hall

Orthoceras(?) sp.

Bryozoa.

Member 8:

Calapoecia sp. Blacksmith Fork.

Streptelasma sp. Goose Creek Ridge, Blacksmith Fork.

Dalmanella cf. *testudinaria* (Hall) and *hamburgensis* (Walcott). Goose Creek Ridge.

Orthoceras(?) sp. Goose Creek Ridge.

Member 7:

Crinoid fragments. Dead Indian Creek.

Dalmenella(?) sp. Crandall Creek, Teton River(?).

Lepeditia sp. Goose Creek Ridge, Crandall Creek, Teton River.

Member 6:

Calapoecia(?) cf. *anticostiensis* Billings. Goose Creek Ridge.

Columnaria sp. Dead Indian Creek.

Halysites gracilis (Hall). Goose Creek Ridge.

Cf. *Protarea richmondensis* Foerste. Goose Creek Ridge.

Streptelasma sp. Goose Creek Ridge.

Pachydictya fenestelliformis(?) Nicholson. Goose Creek Ridge.

Rhinidictya cf. *mutabilis* (Ulrich). Goose Creek Ridge.

MIDDLE ORDOVICIAN

Member 4:

Spheroidal algae. Teton River.

Receptaculites oweni Hall. Livingston Peak.

Lichenaria cf. *typa* Winchell and Schuchert. Rattlesnake Mountain.

Columnaria alveolata Goldfuss. Rattlesnake Mountain, Dead Indian Creek, Crandall Creek.

Halysites gracilis (Hall). Blacksmith Fork.

Streptelasma corniculum Hall. Goose Creek Ridge, Dead Indian Creek (sp. ?), Crandall Creek.

A new cyathophyllid coral. Crandall Creek.

Member 2:

Receptaculites oweni Hall. Crandall Creek.

Halysites gracilis (Hall). Dead Indian Creek, Crandall Creek.

Streptelasma corniculum Hall. Crandall Creek.

Zygospira sp. Crandall Creek.

Clinoceras (?) sp. Crandall Creek.

Member 1, within 5 feet of top (Goose Creek only):

Lophospira sp.

Raphistoma (?) sp.

Cyrtoceras (?) sp.

Orthoceras sp.

Receptaculites oweni Hall.

EARLY ORDOVICIAN (BEEKMANTOWN) (BLACKSMITH FORK ONLY)

Member 4, near top:

A small *Streptelasma*-like coral.

A small cylindrical bryozoan.

Several species of orthid and strophomenoid brachiopods, including a form probably identical with that called by Walcott¹ "*Orthis testudinaria*," from the Upper Pogonip; a form very similar to, and perhaps identical with, the one called by White² "*Strophomena fontinalis*"; and a form which is probably identical with that called by Walcott³ "*Orthis perveta*."

Two species of low-spined gastropods.

Orthoceras sp. (small, annulated form).

¹ C. D. Walcott, "Paleontology of the Eureka District, Nevada," *U.S. Geol. Survey, Monographs*, VIII (1884).

² C. A. White, "Invertebrate Paleontology: Report upon Geographical and Geological Surveys West of the One Hundredth Meridian," IV, Part 1 (1875), Engineer Department, United States Army.

³ *Op. cit.*

Cf. *Bathyurus*? (*Hystricurus*?) *tuberculatus* Walcott.

Ceraurus(?) sp.

An *Isotelus*-like pygidium.

Member 4, 390 feet above base:

Lingula, 2 sp.

Two species of strophomenoid brachiopods; the same as the first two of the three forms mentioned in the fauna collected near the top of Member 4.

Orthoceras sp. (small, annulated form).

Asaphus(?) sp.

Ceraurus(?) sp.

UPPER CAMBRIAN

Member 3.

Billingsella coloradoensis(?) (Shumard). Antler Peak.

Eoorthis cf. *remmicha* Winchell. Teton River.

Obolella(?) sp. Teton River.

Agnostus sp. Teton River.

Ptychoparia(?) sp. Antler Peak, Teton River(?).

Trilobite fragments. Blacksmith Fork.

Member 2:

Unidentifiable organic (algal?) structures. Blacksmith Fork.

Member 1:

Spheroidal algae, $\frac{1}{4}$ inch to 2 inches in diameter. Blacksmith Fork.

Member 0, top (Blacksmith Fork only):

Billingsella coloradoensis (Shumard).

Lingulella manticula (White).

Agnostus.

Ptychoparia.

DISCONFORMITIES

In the following statement is listed the evidence pointing toward discontinuity of sedimentation at the several horizons indicated.

8. Between Members 20 and 21 of the Devonian system (between Devonian and Mississippian?):

a) Member 20B, a limestone, 361 feet thick at Blacksmith Fork, has no lithologically similar representative in any of the other sections, unless it be a 10-foot limestone at Logan, Montana.

b) Member 21 rests on Member 19 at Crandall Creek and at Dead Indian Creek.

c) At Labarge Mountain, Teton River, and Livingston Peak, according to the writer's interpretation, the Madison limestone rests directly on Member 19.

d) Where Members 20B and 21 are absent, the thickness of Member 19 is variable, though not extraordinarily so.

e) Member 21 consists of clastic sediment, chiefly sandstone and black or deeply stained shale.

f) Member 21 contains "a fauna which is different in most of its forms from that of the lower members, and is more like that of the Madison limestone"¹ which overlies it.

7. Between Members 18 and 19 of the Devonian system (between the Jefferson limestone and the Three Forks formation):

a, Sharp lithologic change at this horizon.

b, Member 18 is moderately variable in thickness.

c, In the Teton River section the base of Member 19 contains nodules of limonite. In the Crandall Creek section the same horizon is very deeply iron-stained and carries small geodes of amorphous hematite.

It will be noted that this evidence is entirely circumstantial.

6. Between Members 14 and 15 of the Devonian system (between the main and upper divisions of the Jefferson dolomite):

a) There is a 16-foot sandstone at this horizon in the Labarge Mountain section, and much sandstone in Member 15 in the Teton River section.

b) Members 11-14, with a maximum aggregate thickness of 550 feet, are absent in the Teton River, Antler Peak, and Crandall Creek sections.

c) Members 12-14 are not known north of Labarge Mountain.

d) The Nevada limestone of eastern Nevada includes a lower and an upper fossiliferous zone, separated by from 2,000 to 4,000 feet of barren beds. The Jefferson fauna includes elements of both of the fossiliferous zones of the Nevada, suggesting that the great thickness of the Nevada is due to the presence of medial barren members which are not found in the Jefferson.²

e) In the Snowy Mountain section in Yellowstone Park, Weed³ describes a 25-foot belt of limestone conglomerate at what may be this horizon.

5. Between Members 3 and 4 of the Devonian system (between the basal and main divisions of the Jefferson dolomite):

a) There is a 10-foot bed of sandstone (Member 4) at this horizon in the Labarge Mountain section, and a thinner bed of extremely sandy dolomite in

¹ W. P. Haynes, "The Fauna of the Upper Devonian of Montana, Part 2, The Stratigraphy and the Brachiopoda," *Annals of the Carnegie Museum*, X (1916), 27. It is to be noted that Haynes reached the conclusion that, nevertheless, "there is no sharp break in the record here" (*ibid.*, p. 20).

² See discussion of "The Jefferson Dolomite."

³ W. H. Weed, "Geology of the Southern End of the Snowy Range," *U.S. Geol. Survey, Monographs*, XXXII, Part 2 (1899), chap. vi, p. 206.

the Teton River and Crandall Creek sections marks the base of the main division of the Jefferson.

b) Member 3 was not recognized in the Antler Peak or Dead Indian Creek sections, and in no known section north of Labarge Mountain does it have more than a small fraction of its thickness in that locality.

c) No part of the basal division of the Jefferson was recognized in the Logan section.

4. At the base of the Devonian system:

a) The Silurian system, 750 or more feet thick in northern Utah, is not known in Wyoming or in Montana.

b) The Upper Bighorn dolomite, which underlies the Devonian in western Wyoming and in part of southern Montana, varies greatly in thickness in that region.

c) Members 8 and 9 of the Ordovician system, which elsewhere attain a net thickness of 270 feet, are not found in the Teton River section.

d) In Montana, west of the Gallatin Range, the Devonian system rests on Cambrian strata.

To summarize points (a) to (d), the Devonian system in different parts of the central Rocky Mountain region rests upon the Silurian, the Ordovician, and the Cambrian, respectively.

e) In the Teton River section an erosion surface marks the base of the Darby formation.¹

f) In the Crandall Creek section there is at this horizon a thin conglomerate of small rounded pebbles of dolomite in a matrix of laminated, iron-stained shale, overlain by thin lenses of very deeply iron-stained shale. The basal bed varies notably in thickness within a few yards along the strike, showing that it was deposited upon an irregular surface.

It is obvious that there is a hiatus at the base of the Devonian system wherever the Silurian is missing.

3. At the base of the Silurian system:

a) In the Blacksmith Fork section there is an indubitable erosional disconformity at this horizon.

b) The brachiopod fauna above this disconformity is wholly different from any found below it.

2. Between Members 5 and 6 of the Ordovician system (between the Trenton series and the Richmond series, Lower and Upper Bighorn, Lower and Upper Fish Haven, Lower Bighorn and Leigh):

a) In the Crandall Creek, Dead Indian Creek, and Teton River sections there is a well-marked erosional unconformity at this horizon. (Also at the

¹ Eliot Blackwelder, personal note.

base of the Fish Haven dolomite in the Randolph quadrangle, Utah; but this may perhaps be at the base of the Trenton.)

b) In the Crandall Creek, Dead Indian Creek, and Teton River sections there is at the base of the Upper Bighorn (or Leigh) a breccia or conglomerate of dolomite pebbles in dolomitic or shaly matrix, up to several feet thick; and similar conglomerate occurs at the base of the Upper Fish Haven in the Blacksmith Fork section.

c) Thin lenticular bands of deeply stained shale appear in and above the conglomerate in the Dead Indian Creek section, and the matrix of the conglomerate is deeply iron-stained both there and in the Teton River section.

d) Member 5 is not known south or southwest of Cody, Wyoming.

e) A hiatus between Trenton and Richmond was inferred by Darton¹ in the Bighorn Range from paleontological evidence.

1. At the base of the Middle Ordovician series (Lower Bighorn, Lower Fish Haven):

a) Throughout Wyoming, Montana, and South Dakota, wherever the Bighorn formation (or a formation correlated with it) exists it rests upon strata which are classed as Cambrian, and which certainly in no case are younger than Beekmantown.

b) The basal member of the Bighorn at several localities in Wyoming is a sandstone, of variable thickness, suggesting deposition on an uneven surface.²

c) In the Dead Indian Creek section the base of the Bighorn is a slightly irregular surface.

d) In the Randolph quadrangle the Fish Haven dolomite (all of Richmond age[?]) rests disconformably on the Swan Peak quartzite.

e) The Swan Peak quartzite is entirely missing from the Blacksmith Fork section, although it is several hundred feet thick a few miles northeast and a few miles southwest of that locality.

f) In eastern Nevada the contact between the Lone Mountain limestone and the Eureka quartzite is clearly an erosion surface.

¹ N. H. Darton, "Description of the Bald Mountain and Dayton Quadrangles," *Geol. Atlas U.S.* (Folio 141, 1906), p. 4.

² Cf. N. H. Darton, "A Résumé of the Ordovician Geology of the Northwest," *Bull. Geol. Soc. Amer.*, XVII (1905), 547.

[To be continued]